Modeling and Simulation with Agents

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Introduction and Outline

Agent based simulations can solve problems often not easily solved with other techniques.

Agents are easy to develop and have several characteristics that let them solve difficult problems.

Background
- What are Agents?
- Uses for Agents
- A Formal Definition

Characteristics of Agents
- Emergent Behavior
- Feedback
- Diverse Entities

Economic Applications
- Agent-Based Economics
- Electricity Markets

Applications in Virtual Worlds

Conclusions

What are Agents?

Agents are independent entities that make decisions based on their environment. They have limited knowledge of their environment and try to reach a personal goal.

Examples of Agents

- Birds in a flock
- People trading in the stock market
- People spreading diseases through a region
- Prey vs. Predator models
- Traffic Simulations

Uses for Agents

Agents have been called "a third way of doing science: inductive logic, deductive logic, and agent based modeling" [9]

Agents can show complicated behavior, and they work well in complicated models because they are highly responsive to feedback and can act independently.

Useful in economics, sociology, biological sciences, virtual worlds, and anywhere direct experimentation is difficult.

Formal Definition of an Agent

- Discrete individuals, self contained
- Oriented towards a personal goal
- Able to interact with the environment
- Interact with other agents
- Adapt their behavior?

Characteristics of Agents

I have identified three specific traits that make agents very powerful tools to solve problems.

Defining Characteristics Associated with Agents

- Emergent Behavior
- Feedback
- Agents as Diverse Entities

Emergent Behavior

A series of simple individuals work together and show unexpected behavior that is significantly more complicated than what a single individual could do.

Examples in Nature

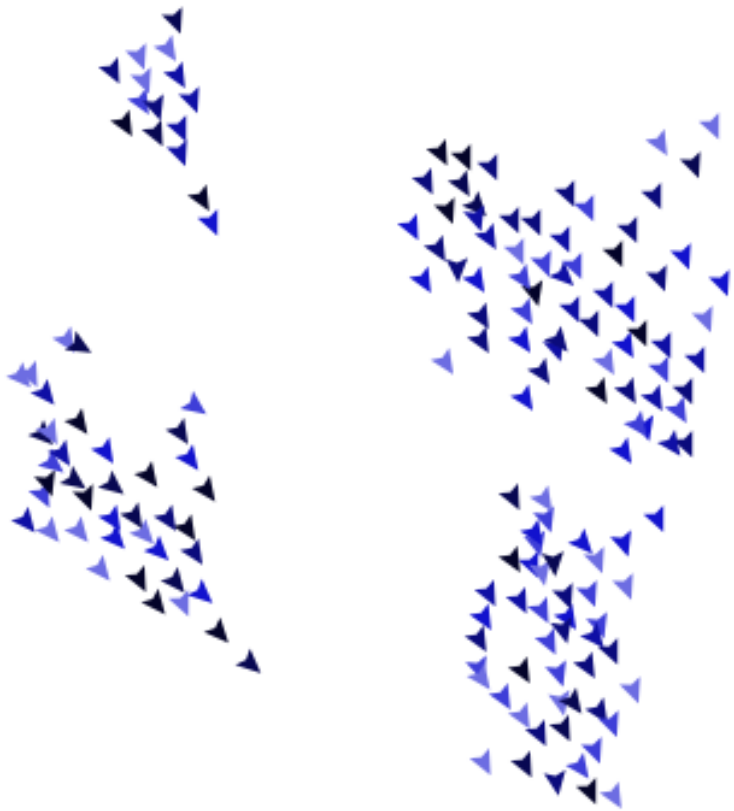
Termites create large mounds with very complicated temperature control structures, even though any individual termite is not complicated.[19]

Flocking

Flocking is a behavior that can emerge with three simple constraints:

- Separation
- Alignment
- Cohesion

Figure created with NetLogo [20].



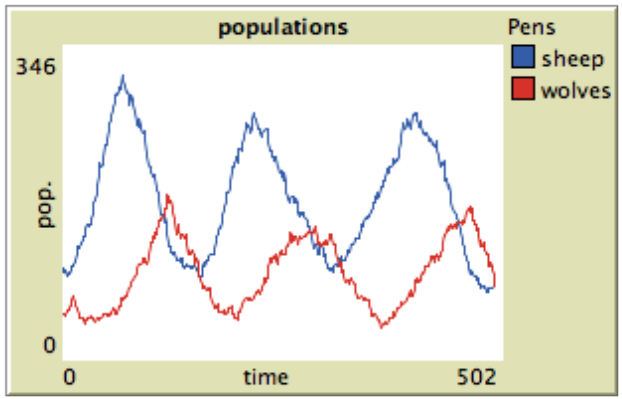
Feedback

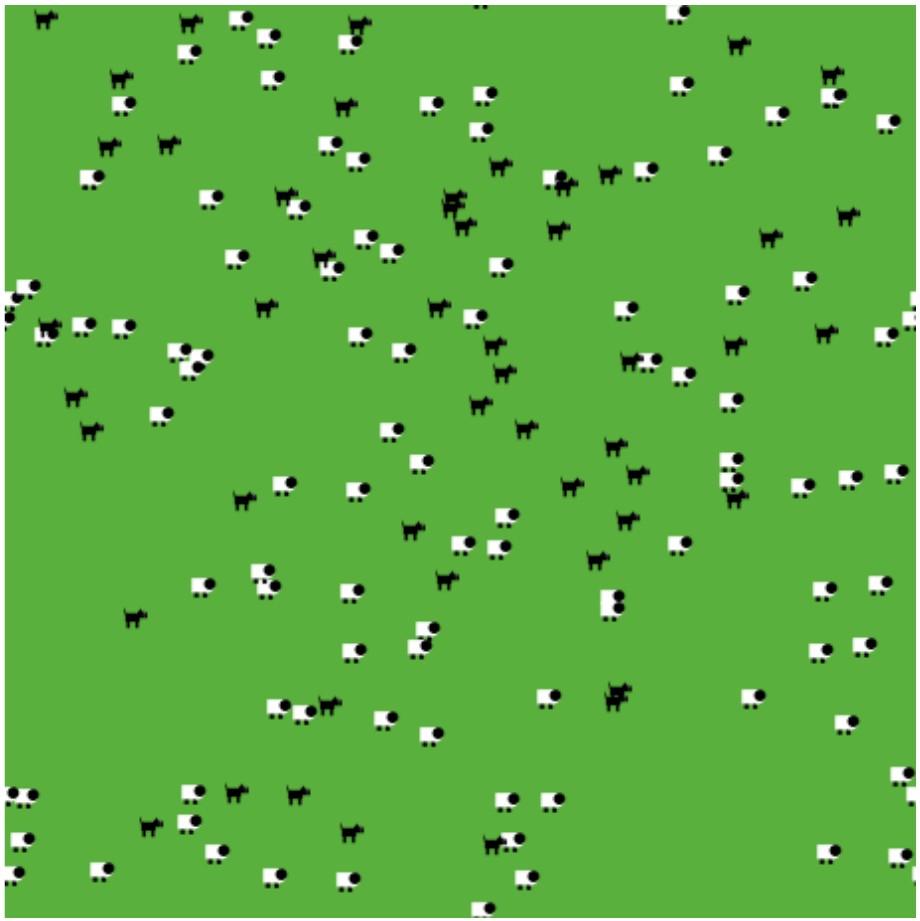
Feedback occurs when past events affect future actions. Through feedback, agents continually adapt to changes in the environment.

Consider the example of retail stores setting a price for a product. In part, the price they set is a function of the price of their competitors.

The iterative nature of agent systems makes accounting for feedback easy! In other systems, the model must explicitly account for the effect of feedback in the equations.

Predator/Prey Models Can Exhibit Population Cycles





Lotka-Volterra Equations for the same model:

$$\frac{dx}{dt} = Ax - Bxy$$
$$\frac{dy}{dt} = -Cy + Dxy,$$

Diverse Entities

It's possible to have multiple types of agents.

Sheep Wolves

New entities are easy to develop and add to a model. Adding a simple wolf that wanders around is easier than doing differential equations!

In Economics

Individual traders, consumers, corporations, financial institutions, and governments can be modeled as a different types of agents.

Agent-Based Economics

An agent based approach is effective because:

- Complicated two-direction feedback in economic systems
- More flexible and powerful than deterministic methods and purely mathematical models
- Agents may adapt over the simulation
- Individuals are easy to understand, the entire system is not

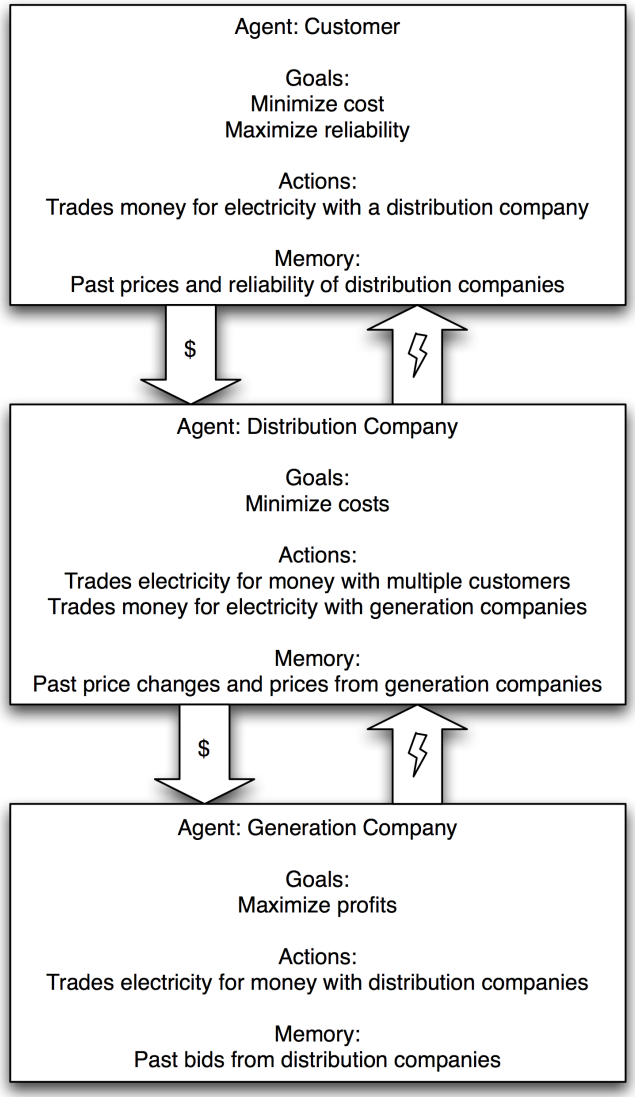
Typically, economic agents, such as individual traders or institutions are modeled, in addition to external influences such as governments, laws and regulations, and environmental factors.

Electricity Markets

These complicated systems lend themselves well to agent based modeling.

- Feedback
- Diverse Entities
- Simple to Change

In this example prices fluctuated for a while before converging. Also, it was found entities would seem to collude even though no communication of that type was possible between them. [16, 9]



In Virtual Worlds

Agents make virtual worlds more immersive and believable [4].

NPCs (non player characters) act less rigidly.

In video games, such as Oblivion by Bethesda Softworks, players find the agent based NPCs to be interesting to interact with and watch [17].

Conclusions

Agents have very interesting characteristics that make them very useful in a variety of models and simulations.

With the falling price of computer hardware, these relatively computationally expensive simulations are becoming better options. Hardware is much cheaper than hiring more modelers and mathematicians.

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